
Experience with Osseointegrated Implants Placed in Irradiated Tissues in Japan and the United States

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A survey was undertaken to analyze osseointegrated implants placed in irradiated maxillae and mandibles. It was found that nine centers in Japan and two centers in the United States had placed 228 implants in 44 patients. Of 228 implants, 59 were placed in the maxilla, 169 in the mandible. Three of 169 implants placed in irradiated mandibles were removed; 17 of 59 were removed from maxillae. One hundred nineteen implants were placed in the mandible without adjunctive hyperbaric oxygen treatment, of which only 2 were removed. From these results, it is suggested that osseointegrated implants can be placed in the irradiated mandibles of selected patients without hyperbaric oxygen treatment.

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Key words: hyperbaric oxygen treatment, irradiation, multicenter study, osseointegrated implants

The influence of radiotherapy on osseointegration is controversial. Especially for intraoral implants, there is a paucity of treatment data.¹⁻⁵ Recently, a Japanese multicenter study⁶ of osseointegrated implants placed in irradiated tissues was reported in which it was suggested that endosseous implants in the mandible provide a high degree of predictability, while in the maxilla the predictability is fairly low even when adjunctive hyperbaric oxygen (HBO) is used. However, the numbers of patients and implants in the Japanese multicenter study were limited, and only trends were indicated.

To reach more definitive conclusions, this multicenter study presents the analysis of 228 osseointegrated implants placed in irradiated tissues from the data of nine centers in Japan and two centers in the United States.

Materials and Methods

All patients surveyed had been treated with bone-anchored prostheses using Brånemark system implants (Nobel Biocare, Göteborg, Sweden) following malignant tumor surgery and radiotherapy. Surgical and prosthodontic procedures involving the implants were provided according to the Brånemark protocol.⁷ Patients who had radiotherapy after implant placement, and implants that were placed in bone grafts after radiotherapy, were excluded from this study. Survival rates were calculated in the following way:

$$\text{Survival rate} = \frac{(\text{no. of implants placed} - \text{no. of implants buried} - \text{no. of implants removed}) \times 100}{(\text{no. of implants placed} - \text{no. of implants buried})}$$

The survey of Japanese centers was the same as in the previous study.⁶ Of the 63 Japanese centers contacted, 9 responded as having placed Brånemark implants in irradiated tissues and 26 responded as having not done so. In this study, the data from two U.S. centers were combined: data were supplied by the Section of Oral and Maxillofacial Surgery, Department of Dental Specialties, Mayo Clinic, and by the Department of Oral and Maxillofacial Surgery, University of Washington.

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Table 1 Follow-Up Time

		Follow-up time (mo)					Total	
HBO		1-12	13-24	25-36	37-48	49+		
Japanese study	(-)	Patients treated	6	6	2	0	1	15
		Implants placed	37	32	6	0	4	79
	(+)	Patients treated	2	0	2	3	0	7
		Implants placed	8	0	11	12	0	31
United States study	(-)	Patients treated	1	0	3	3	8	15
		Implants placed	3	0	13	22	44	82
	(+)	Patients treated	2	0	2	0	3	7
		Implants placed	10	0	11	0	15	36

HBO = hyperbaric oxygen therapy.

Table 2 Japanese Data: Correlation Between Location of Implant and Survival Rate

	HBO	Patients treated	Implants placed	Implants buried	Implants removed (< 1 y)	Implants removed (> 1 y)	Survival rate (%)
Maxilla	(-)	5	22	6	3	3	62.5
	(+)	4	17	2	1	2	80.0
Mandible	(-)	13	57	1	2	0	96.4
	(+)	3	14	0	1	0	92.9
Total	(-)	15	79	7	5	3	88.9
	(+)	7	31	2	2	2	86.2

Table 3 Japanese Data: Correlation Between Irradiation Dose and Implant Failure

		Irradiation dose (Gy)					
		< 25	26-35	36-45	46-55	56-65	> 66
HBO(-)	Placed	4	43	4	11	17	0
	Buried	0	6	0	1	0	0
	Removed	1	4	1	2	0	0
HBO(+)	Placed	0	0	13	15	0	3
	Buried	0	0	0	2	0	0
	Removed	0	0	1	2	0	1

Results

Japanese Centers. Of the 22 patients included in the Japanese results, 7 received adjunctive HBO (HBO group) and 15 did not (non-HBO group) (Table 1). Generally, adjunctive HBO was administered in 20 “dives” before and 10 “dives” after implant placement, with 2.4 absolute atmospheric pressure for 90 minutes.⁸

Of the 39 implants placed in the maxilla, 22 were in the non-HBO group and 17 were in the HBO group. The implant survival rate was 62.5% for the non-HBO group and 80.0% for the HBO group. Of the 71 implants placed in the mandible, 57 were in

the non-HBO group and 14 were in the HBO group. The implant survival rate was 96.4% for the non-HBO group and 92.9% for the HBO group (Table 2).

The correlation between irradiation doses and implant failures is indicated in Table 3. Some implants were removed even in patients who received low-dose irradiation. The time intervals from radiotherapy to implant surgery are indicated in Table 4.

Implants of 7 mm or 10 mm in length were removed more frequently than others. Of the 66 implants that were 13, 15, 18, or 20 mm in length, only 2 were removed (Table 5).

United States Centers. The numbers of patients in the HBO and non-HBO groups were similar in the

Table 4 Japanese Data: Time Interval from Radiotherapy to Implant Surgery

	Time interval (mo)						
	1-12	13-24	25-36	37-60	61-120	121-180	181-240
Placed	25	11	34	11	19	5	5
Buried	3	0	0	4	0	1	1
Removed	4	1	2	1	0	2	2

Table 5 Japanese Data: Correlation Between Implant Length and Implant Failure

		Implant length (mm)					
		7	10	13	15	18	20
Maxilla	Placed	6	17	5	8	3	0
	Buried	1	3	2	1	1	0
	Removed	3	6	0	0	0	0
Mandible	Placed	6	15	2	20	18	10
	Buried	1	0	0	0	0	0
	Removed	1	0	0	0	1	1
Total	Placed	12	32	7	28	21	10
	Buried	2	3	2	1	1	0
	Removed	4	6	0	0	1	1

Table 6 United States Data: Correlation Between Location of Implant and Survival Rate

	HBO	Patients treated	Implants placed	Implants buried	Implants removed (< 1 y)	Implants removed (> 1 y)	Survival rate (%)
Maxilla	(-)	4	20	1	8	0	57.9
	(+)	0	0	0	0	0	—
Mandible	(-)	13	62	1	0	0	100.0
	(+)	7	36	4	0	0	100.0
Total	(-)	15	82	2	8	0	86.0
	(+)	7	36	4	0	0	100.0

Table 7 United States Data: Correlation Between Irradiation Dose and Implant Failure

		Irradiation dose (Gy)					
		< 25	26-35	36-45	46-55	56-65	> 66
HBO(-)	Placed	0	10	0	15	36	21
	Buried	0	0	0	1	1	0
	Removed	0	0	0	2	6	0
HBO(+)	Placed	0	0	5	0	31	0
	Buried	0	0	1	0	3	0
	Removed	0	0	0	0	0	0

Japanese and U.S. centers. Of the 118 implants placed in irradiated tissues, 82 were in the non-HBO group and 36 were in the HBO group (Table 1).

All 20 of the implants placed in the maxilla were in the non-HBO group. The survival rate of the non-HBO group was 57.9%. Of the 98 implants placed in the mandible, 62 were in the non-HBO group and 36 were in the HBO group. The survival rate for both

mandibular groups was 100% (Table 6).

The correlation between irradiation doses and implant failures is indicated in Table 7. The time intervals from radiotherapy to implant surgery are indicated in Table 8. There were no implants removed for the 13 to 24 months' time interval.

Table 9 indicates the correlation between implant length and implant failure.

Table 8 Japanese Data: Time Interval from Radiotherapy to Implant Surgery

	Time interval (mo)						
	1-12	13-24	25-36	37-60	61-120	121-180	181-240
Placed	0	41	8	20	39	10	0
Buried	0	2	2	1	0	1	0
Removed	0	0	2	0	6	0	0

Table 9 United States Data: Correlation Between Implant Length and Implant Failure

		Implant length (mm)					
		7	10	13	15	18	20
Maxilla	Placed	0	4	2	8	6	0
	Buried	0	1	0	0	0	0
	Removed	0	1	2	5	0	0
Mandible	Placed	0	15	32	40	11	0
	Buried	0	3	2	0	0	0
	Removed	0	0	0	0	0	0
Total	Placed	0	19	34	48	17	0
	Buried	0	4	2	0	0	0
	Removed	0	1	2	5	0	0

Discussion

The reports on implants placed in irradiated tissues have focused mainly on extraoral implants.⁹⁻¹² The reports of intraoral implants placed in irradiated jaws are very limited and describe only a few cases.¹⁻⁵ Albrektsson¹ reported on 10 maxillary and 21 mandibular implants placed in irradiated jaws without failure. Taylor and Worthington² reported on 21 mandibular implants placed without failure, 15 of which were placed with HBO. Franzen et al³ reported on 20 mandibular implants with only 1 failure. Niimi et al⁴ reported on 12 maxillary implants placed with HBO, 2 of which were removed and 1 of which was buried. Eckert et al⁵ reported on 89 mandibular implants with 1 failure, and 22 maxillary implants with 8 failures; however, 6 of the 8 lost implants occurred in one patient with severely compromised bone quality and quantity, where normally a high incidence of failing implants would be expected even without radiation exposure.

This study analyzed 169 mandibular implants and 59 maxillary implants. For the mandible, the survival rate was relatively high even when HBO had not been used. From these results it is suggested that osseointegrated implants can be placed in the irradiated mandibles of selected patients with the greatest care and without HBO. However, the follow-up time involved with those patients was not enough to deter-

mine whether HBO is not necessary for all mandibular situations, because the microvascular circulation diminishes with time for many years and the effect of HBO continues for many years.¹³

For the maxilla, the number of implants reported was too low to draw any firm conclusions. One might speculate that poor bone quality of the maxilla, which has not been evaluated in this study, could be related to a high failure rate. The effect of HBO on the implants placed in the irradiated maxilla has not been clarified; in the HBO group, only four patients were analyzed, and in the non-HBO group, six implants were lost in one patient who exhibited other risk factors.

In the Japanese data, implants were frequently removed, even for low-dose irradiated patients, which suggests that implant loss is likely related to other risk factors. This result concurs with the data for extraoral implants¹¹; it suggests that the risks of implant failure must be recognized even in low-dose irradiated patients, and especially in high-density bone (mandible, frontal bone, and zygoma), which generally receives higher biologic irradiation injury and has reduced vascularity before irradiation injury.

The time interval from radiotherapy to implant surgery is an important factor for implant placement. When the Japanese and the U.S. data are combined, only 1 of 52 implants was removed over 13 to 24 months. It is during this period that the incidence of

trauma-induced osteoradionecrosis after radiotherapy is lowest.¹³ An improvement in the bone-healing capacity by a factor of almost 2.5 during a 12-month period following irradiation¹⁴ could partially explain this result.

Implant length may be critical to implant survival. In the Japanese study, implants of 7 mm or 10 mm in length had higher failures rates than others, especially in the maxilla. However, in the U.S. data, implants of 13 or 15 mm in length had high failure rates as well. These results suggest that the possibility of failure can exist for any length of implant in some situations.

Conclusion

In data accumulated from nine Japanese and two U.S. treatment centers, 3 of 169 implants placed in irradiated mandibles were removed. Of the 119 implants placed without HBO, only 2 were removed. Seventeen of 59 implants placed in irradiated maxillae were removed. These results suggest that endosseous implants can be placed in the irradiated mandibles of selected patients with the greatest care and without HBO and can be expected to survive.

References

1. Albrektsson T. A multicenter report on osseointegrated oral implants. *J Prosthet Dent* 1988;60:75-84.
2. Taylor TD, Worthington P. Osseointegrated implant rehabilitation of the previously irradiated mandible: Result of a limited trial at 3 to 7 years. *J Prosthet Dent* 1993;69:60-69.
3. Franzen L, Rosenquist JB, Rosenquist KI, Gustafsson I. Oral implant rehabilitation of patients with oral malignancies treated with radiotherapy and surgery without adjunctive hyperbaric oxygen. *Int J Oral Maxillofac Implants* 1995;10:183-187.
4. Niimi A, Ueda M, Kaneda T. Maxillary obturator support by osseointegrated implants placed in irradiated bone: Report of cases. *J Oral Maxillofac Surg* 1993;51:804-809.
5. Eckert SE, Desjardins RP, Keller EE, Tolman DE. Endosseous implants in an irradiated tissue bed. *J Prosthet Dent* 1996;76:45-49.
6. Niimi A, Fujimoto T, Nosaka Y, Ueda M. A Japanese multi-center study of osseointegrated implants placed in irradiated tissues: A preliminary report. *Int J Oral Maxillofac Implants* 1997;12:259-264.
7. Brånemark P-I, Zarb G, Albrektsson T. *Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry*. Chicago: Quintessence, 1985.
8. Marx R, Ames J. The use of hyperbaric oxygen therapy in bony reconstruction of the irradiated and tissue-deficient patient. *J Oral Maxillofac Surg* 1982;40:412-420.
9. Parel SM, Tjellström A. The United States and Swedish experience with osseointegration and facial prostheses. *Int J Oral Maxillofac Implants* 1991;6:75-79.
10. Wolfaardt JF, Wilkes GH, Parel SM, Tjellström A. Craniofacial osseointegration: The Canadian experience. *Int J Oral Maxillofac Implants* 1993;8:197-204.
11. Granström G, Bergström K, Tjellström A, Brånemark P-I. A detailed analysis of titanium implants lost in irradiated tissues. *Int J Oral Maxillofac Implants* 1994;9:653-662.
12. Tolman DE, Taylor PF. Bone-anchored craniofacial prosthesis study: Irradiated patients. *Int J Oral Maxillofac Implants* 1996;11:612-619.
13. Marx RE, Johnson RP. Studies in the radiobiology of osteoradionecrosis and their clinical significance. *Oral Surg Oral Med Oral Pathol* 1987;64:379-390.
14. Jacobsson M. On bone behavior after irradiation [thesis]. Göteborg, Sweden: Univ of Göteborg, 1985.